SEMINAR REPORT

CENTER FOR THE STUDY OF INTELLIGENCE

CENTRAL INTELLIGENCE AGENCY

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CENTER FOR THE STUDY OF INTELLIGENCE

13 July 1976

Sixth Intelligence Analysis Seminar:

The Utility of System Dynamics Models to Intelligence Analysis

The development of new methodologies to aid and improve intelligence analysis is a field receiving considerable attention today. Well before the Church and Pike Committees urged the intelligence community to this task, there were dedicated groups of CIA officers in several quarters of the Agency at work on new methodological tools for analysis. At this point, in fact, we have available about "100 pounds of methodology and one-half ounce of applications," in the words of one fervent supporter of the new approaches.

It was with a view to familiarizing a cross section of intelligence community officers with some of the potential applications of these new approaches that the CSI sponsored an afternoon seminar on 22 June to discuss one of the more important and promising new methodologies: System Dynamics.*

*System dynamics is described as a methodology for setting forth cause and effect relationships of all factors which bear on a single problem or issue. The intuitive judgments about these relationships are quantified into mathematical formulas which, when combined in a computer program, constitute a "model" of the interaction of the problem or issue. This model can be used in numerous ways to assess analytical possibilities in connection with the issue or problem.

Some 40 officers attended and heard presentations on three System Dynamics (SD) models developed within CIA for use in analysis. (A summary of these presentations and a list of the attendees is contained at the end of this report).

Although there was some skepticism expressed in the seminar discussion over the breadth of SD's applicability to political analysis, there was wide agreement among the participants that the SD modeling process is making solid strides and developing utility as an important analytical tool that also has applications in collection guidance and other operational pursuits. Major points made at the seminar concerning SD applications, as well as some of its possible limitations, are described below.

SD Applications to Analysis:

In the words of one participant, SD models provide intelligence analysts with a new way of thinking about a problem they are challenged to analyze--that of the causal relationships among all recognizable factors that have a bearing on their subject. At the very least, such an approach can provide a better view of the secondary chain of reactions to a given set of actions or events. It follows that SD models can provide a useful tool in the analysis of the results of variant scenarios; that is, in answering the "what if" kind of question. This has been demonstrated by CIA's most advanced analytical model--on the China petroleum

industry. Because the cause and effect relationship has been integrated into the model, the model can provide a specific observation and statement of the "effect" of various postulated actions, policies, and decisions. SD models can also forecast what will transpire in the future given a straight line projection of current policies--the kind of question Mr. Kissinger often seeks to have answered. The SD approach can bring system, structure and breadth of analysis to a problem. Using a computer, the model can hold, sort, and combine details on complex problems that go beyond the normal capacity of a single human brain, or possibly even a group of brains.

But there are some vital ingredients to a well constructed SD model:

a. the maximum number of available facts about the causal relationships bearing on the problem must be assembled during the model building.

b. the best intuitive judgments must be brought to bear in working up the nature of the causal relationships, particularly when the facts are not clear, but must be adduced. These adductions must be kept to a minimum to produce the most reliable working model.

c. the model must be carefully "tuned" by testing to see that it is properly and logically

responding to the questions and stimuli it is given. Here a knowledge of historical development can act as a checking device on what the model is forecasting for the future.

The process used in constructing an SD model can deliver an interdisciplinary analytical product if specialists from a variety of disciplines discuss and provide what they deem to be important causal relationships for formulation into the model. There is a potential added advantage in blocking out individual analyst biases because the judgments of many specialists are brought together and programmed into a model which the computer holds and sorts mechanically with no emotional bias.

Application to Intelligence Operations: Collection Guidance:

There was much discussion at the seminar of SD applications in the field of collection guidance. By use of the models, it appears theoretically possible to determine which factors are of particular influence or importance in a given situation. This is especially useful if the factors have not been previously recognized as important. Attention could be focused upon collection of information bearing on the key factors, with less attention, or perhaps no effort, expended upon issues which have no significant impact on the problem at hand.

In this way the application of SD to analytical problems could become a tool for the management of resources. This would be particularly useful where resources are highly limited as in human clandestine collection. As an illustration, the China petroleum industry model, according to its developers, demonstrated that population growth, night soil use, and oil exports are all key factors in influencing petroleum output as well as other areas of the Chinese economy (see detailed discussion in presentations section). On the other hand, the state of Chinese petroleum technology, the amount of oil reserves, and such factors as social unrest have little impact upon the petroleum picture in China. If accepted as valid, these findings could provoke reassessment of collection priorities on Chinese petroleum requirements with greater emphasis on the three key factors. The models in the long run may give us some better handle on just how much we should be emphasizing capabilities like photography and SIGINT on "hard" factors like production and technology as opposed to human collection against "soft" things like plans and policy.

Other Intelligence Operations Applications:

A number of other applications for SD in CIA's intelligence processes were discussed and suggested by seminar participants, although these fall largely into the category

of "unproved" in the sense that CIA has not yet sufficient experience in such applications to reach valid conclusions. Among these is the possible application of the models to Agency political action operations. If the Agency had an accurate model of a major problem in a foreign nation, the United States could advise that nation of the pitfalls of adopting policies the U.S. opposed and the benefits of policies the U.S. favored. In another vein, SD could be applied to modeling a proposed covert action plan to predetermine if the scheme was going to have the desired result. If it did not, variations could be experimented with on the model until a more desirable result was reached. One participant expressed the view that a model of the political dynamics of a nation should be able to pinpoint the key groups within that nation which exert the most leverage on its policies. There would be obvious applications for such information in analysis and operations, both overt and covert. It should be noted, however, that we do not yet have models at hand that can be used along these lines.

SD models were also suggested as instructive instruments for rapid training of case officers going abroad to bring them up to speed on the intricacies of a particular situation or scenario. Since the models are computer based, they are portable and potentially could be used in the field.

SD models offer a basis for compatible and interleaved analysis of differing subjects, if there is careful liaison between the developers. The two China models discussed at the seminar (the petroleum industry and population/food production) will be integral in their final stage. The integrated result will come closer than either of the two models separately to a total model of the Chinese economy, although it will not be that.

Limitations and Cautions:

There are drawbacks to SD modeling for intelligence analysis, some of which were described by participants at the seminar. One participant noted that in attempting to use SD for indicators of change in Peruvian foreign policy, the model seemed to narrow rather than broaden the range of analysis. In dealing with competition between Peruvian generals for leadership, the model would not act rationally, even within the bounds of the indiscipline and irrational behavior patterns of the "typical Peruvian general."

The effective and confident translation of data, especially soft data requiring intuitive judgments, into mathematical formulas that can be programmed into the computer is still a very difficult area. One participant described it more as an art and an "act of faith" than a science, especially when applied to soft judgments about intentions,

social behavior, etc., that require nuances and subtleties. Moreover, the formula building and tuning process require very careful work and are time-consuming, which tends to make SD modeling impractical for sudden crisis situations requiring instant analysis.

Another criticism was that the models when projected well into the future, seem always to predict some sort of collapse in the situation. While models may be quite accurate on short-range forecasts (a function of a large proportion of fact in the model and few intuitive judgments) they tend to become far less accurate as the time into the future increases. Too many intuitive judgments poorly introduced as cause and effect formulas may flaw the model: "inestimable variables may weaken the predictive accuracy of the model." The dissenters caution that "the intuitive judgments that go into each model will reflect any weaknesses of those who reach the judgments," while the proponents answer that, "at least one has the assumptions out in the open where they can be lined up, discussed and perhaps improved."

The skeptics also note that the logic which enters into judgments on cause-effect relationships in the models is our own western logic--a product of the U.S. educational and value system. There is some concern that this might not be the

logic with which foreign leaders approach their own national and foreign problems. This is, however, also a weakness of intuitive analysis.

The Presentations:

Three presentations were made at the opening of the seminar. An overview was given by [redacted], 25X1A Chief of the Information Science Training Branch of the Functional Training Division of OTR. He said that SD was a methodology intended to maximize the use of judgment and intuition of which CIA has a great deal, and that it is also a system designed to take maximum advantage of expertise. SD provides an excellent framework for multi-disciplinary work; it has the advantages of simplicity and ease of understanding. SD is useful for analysis, management, covert action, and collection guidance.

25X1A [redacted] noted that SD modeling itself may become a collection target if it begins to be used on a wide scale. He stated that Dzherman M. Gvishiani* is attempting to use SD models of Soviet domestic problems for a series of policy recommendations to senior Soviet leaders. He is a student of U.S. management methods and has sent teams to the United States

*Dzherman M. Gvishiani is a son-in-law of Soviet Premier Kosygin, and in the USSR is a Deputy Chairman of the State Committee for Science and Technology. On the international scene, he is the Chairman of the International Institute for Applied Systems Analysis.

to learn the SD process. Iran has constructed an SD model of Iranian national processes to support its planning. All of these models would be of intelligence interest to the U.S., 25X1A according to [redacted]

A major application of SD to intelligence analysis was then presented by a team composed of [redacted] of the Center 25X1A for Development of Analytical Methodology of ORD; David 25X1A [redacted] on the project, 25X1A [redacted] of East Asia Division of the DDO. They discussed the China petroleum industry model that had been built and is currently functioning. It was constructed using over 400 cause and effect formulas. Nine areas were factored into the model: petroleum, coal and other energy sources, capital goods production, agricultural production, transportation, consumer goods production, labor and population, exports and imports, and resource allocation. In the view of its developers, the model has creditable accuracy because it has demonstrated petroleum production figures that have been a close approximation to several of our best estimates of past petroleum production in China, although the model was not fed these production figures.

Current factual data fed into the model results in a prediction of a petroleum production increase in the 1980's

without marked growth of exports until the 1990's when China must export petroleum to pay for food imports. China will run out of oil resources shortly after 2000, according to this projection if production remains at the predicted levels.

In the petroleum model the three issues of greatest sensitivity (those in which the slightest variance has a major impact on the petroleum picture) were population, recycling of night soil, and exports. The most minor change in recycling night soil--a surprisingly significant factor--can radically alter the availability in China of petroleum products since it impacts heavily on the use of petroleum for chemical fertilizer and thus on total domestic food production--any shortage of which stimulates oil export for foreign exchange with which to import food. The areas in which there was little sensitivity were petroleum technology, reserves, and social disturbances. According to test runs on the model, the Chinese will make up for lack of sophisticated petroleum technology by maximizing low technology machinery. China will be using such large amounts of petroleum in the year 2000 that doubling the present reserve estimate only delays the exhaustion of stocks by a few years at best.*

*The China petroleum model is available for experimental use by interested analysts. A Working Paper specifying some of the results of the model thus far was published as CIA-319/00005-76 in June 1976 under the title, "Projections of Chinese Crude Oil Production and Exports and on Chinese Coal Supplies Utilizing a System Dynamics Computer Simulation Model."

25X1A [redacted] of the Biomedical Science Branch of the Life Sciences Division of OSI, described his program for the creation of an SD model of the Chinese food and population problem. This will be compatible with the petroleum model already built, but much work remains in the construction

25X1A of [redacted] model. The model is intended to help answer the question as to whether China will really be able to play the role of a super-power in the future. His assumption is that to do so it must at least solve its food and population problems. China had a large population explosion in the 1950's resulting from lowered infant mortality rates and gains against infectious diseases in the urban areas. It is inevitably going to have another giant population explosion as its spread of health and sanitation measures to the rural population (some 85% of the total) takes hold. While China wants instant zero population growth in [redacted] view, 25X1A this will take some time and a great deal of effort. The population sector of this model has just been tentatively diagrammed and the agricultural side has yet to be tackled.

25X1A [redacted] of the Analytical Techniques Group of OPR described his initial attempts at developing an SD model from an existing OCI paper on Peruvian political dynamics and governmental stability. He foresaw as benefits in doing this: a) that it would provide a check upon the analysts' assumptions; b) refine the analysts understanding;

and c) point out gaps in knowledge. He did not in the end fully carry out the construction of a model because he found the statements in the Peruvian paper to be so qualitative in nature that it was difficult successfully to convert them to numbers for use in the formulas. Further, he determined that the expected benefits from the model would not be worth the time needed to tune it. [redacted] believes 25X1A that a model of Peruvian dynamics with continuing validity would have to be retuned at least every year to be accurate in forecasting. He believes it unrealistic to conclude that one value can vary in isolation from other values in the model--a situation which is not the normal pattern of life. Some of his equations worked out well over the recent past, but they did not seem particularly realistic when applied to the distant future.

25X1A NOTE: Comment on this report should be directed to [redacted] CSI Staff, extension 2193 or 3281.

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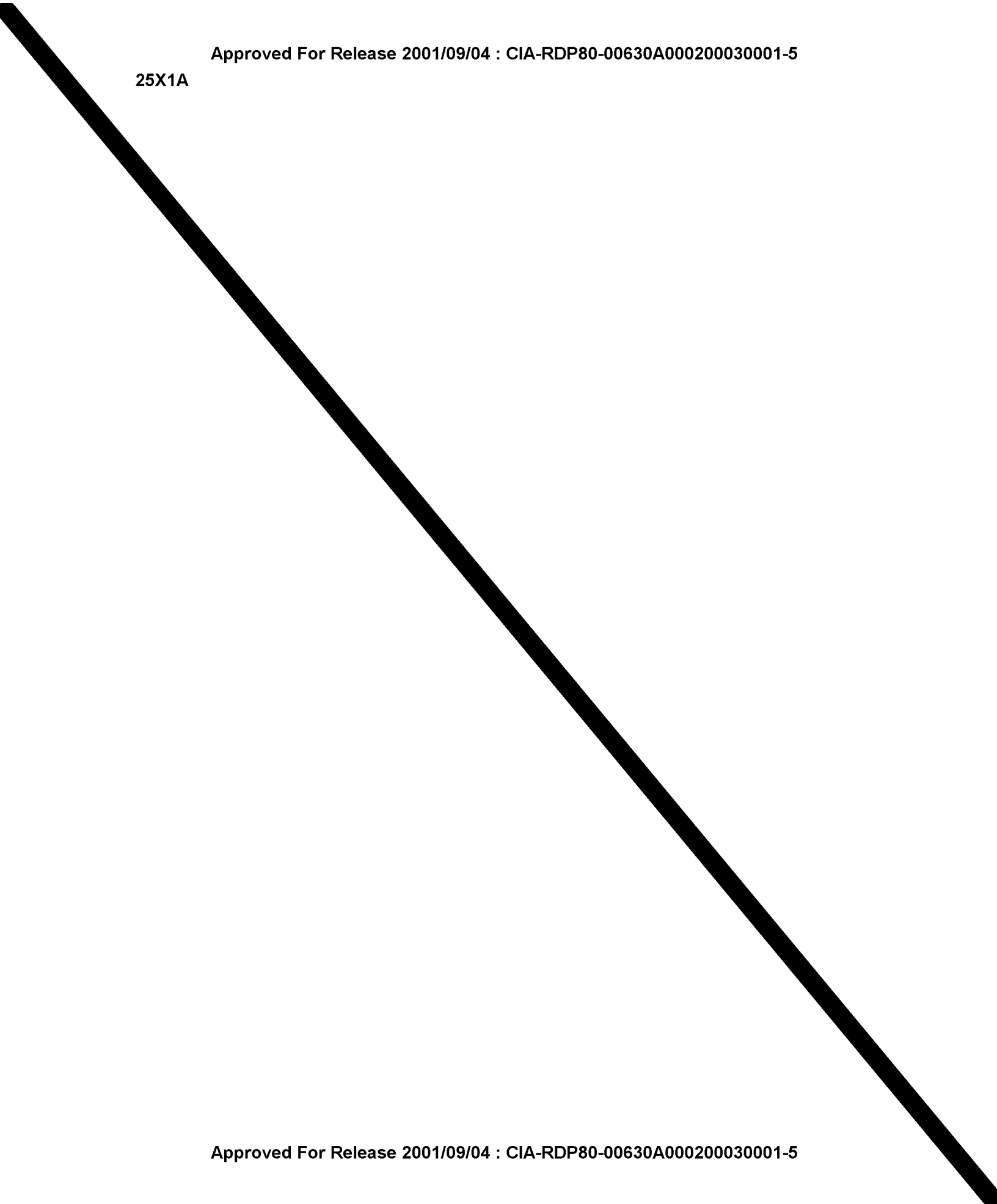

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